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08/856,116	05/14/97	CHEN F	AMAT/1931

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EXAMINER	
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ART UNIT	**PAPER NUMBER**
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Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner of Patents and Trademarks

Office Action Summary	Application No. 08/856,116	Applicant(s) Chen et al.
	Examiner Bernard Souw	Group Art Unit 2814

☒ Responsive to communication(s) filed on *Dec 3, 1999*

☐ This action is **FINAL.**

☐ Since this application is in condition for allowance except for formal matters, **prosecution as to the merits is closed** in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11; 453 O.G. 213.

A shortened statutory period for response to this action is set to expire *3* month(s), or thirty days, whichever is longer, from the mailing date of this communication. Failure to respond within the period for response will cause the application to become abandoned. (35 U.S.C. § 133). Extensions of time may be obtained under the provisions of 37 CFR 1.136(a).

Disposition of Claim

☒ Claim(s) *1-21* is/are pending in the applicat

Of the above, claim(s) *9, 10, and 19* is/are withdrawn from consideration

☐ Claim(s) _____ is/are allowed.

☒ Claim(s) *1-8, 11-18, 20, and 21* is/are rejected.

☐ Claim(s) _____ is/are objected to.

☐ Claims _____ are subject to restriction or election requirement.

Application Papers

☐ See the attached Notice of Draftsperson's Patent Drawing Review, PTO-948.

☐ The drawing(s) filed on _____ is/are objected to by the Examiner.

☐ The proposed drawing correction, filed on _____ is ☐ approved ☐ disapproved.

☐ The specification is objected to by the Examiner.

☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. § 119

☐ Acknowledgement is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d).

☐ All ☐ Some* ☒ None of the CERTIFIED copies of the priority documents have been

☐ received.

☐ received in Application No. (Series Code/Serial Number) _____ .

☐ received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

*Certified copies not received: _____

☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. § 119(e).

Attachment(s)

☐ Notice of References Cited, PTO-892

☐ Information Disclosure Statement(s), PTO-1449, Paper No(s). _____

☐ Interview Summary, PTO-413

☐ Notice of Draftsperson's Patent Drawing Review, PTO-948

☐ Notice of Informal Patent Application, PTO-152

--- SEE OFFICE ACTION ON THE FOLLOWING PAGES ---

DETAILED ACTION

1. Upon further consideration, the finality of the previous Office action mailed on 07/09/1999 (Paper No.11) is withdrawn.

Objections to the Disclosure

2. The following is a quotation of 37 CFR 1.71(a)-(c):

> (a) The specification must include a written description of the invention or discovery and of the manner and process of making and using the same, and is required to be in such full, clear, concise, and exact terms as to enable any person skilled in the art or science to which the invention or discovery appertains, or with which it is most nearly connected, to make and use the same.
>
> (b) The specification must set forth the precise invention for which a patent is solicited, in such manner as to distinguish it from other inventions and from what is old. It must describe completely a specific embodiment of the process, machine, manufacture, composition of matter or improvement invented, and must explain the mode of operation or principle whenever applicable. The best mode contemplated by the inventor of carrying out his invention must be set forth.
>
> (c) In the case of an improvement, the specification must particularly point out the part or parts of the process, machine, manufacture, or composition of matter to which the improvement relates, and the description should be confined to the specific improvement and to such parts as necessarily cooperate with it or as may be necessary to a complete understanding or description of it.

The specification is objected to under 37 CFR 1.71 because:

(a) On page 7, lines 1-2, while referring to Fig.8 the disclosure recites, " ... etched to form a ***plug*** 20 through the barrier layers 15, 16 and the dielectric layer 12 as shown in Fig.8."

(b) On page 7, lines 4-5, while referring to Fig.10 the disclosure recites, " ...portion of the Si_xN_y layer 30 formed on the ***bottom of the plug 20*** .... as shown in Fig.10."

(c) On page 7, lines 6-8, the disclosure recites, "Additionally, Cu can be sputter ***deposited in the plug*** or Cu can be deposited using electroplating to complete the ***fill of the plug*** ."

The recitations (a)-(c) clearly shows that Applicants are using the word ***"plug"*** to mean a "hole" or "opening" in a solid substrate.

However, this is different than Applicants' own definition of a plug, i.e., as recited on page 5/lines 8-9, "The present invention provides a process sequence and related hardware to form a ***copper plug*** ...", which is consistent with Applicants' earlier recitation on page 2/lines 12-13, "The generic structure is referred to as a *plug*. If the *plug* is connected to silicon or polysilicon, the *plug* is a contact. If the *plug* is connected to a metal, the *plug* is a via".

The recitations in (a) to (c) above also contradict the commonly accepted terminology for *"plug"*. The Merriam Webster's Collegiate Dictionary (10th edition, page 895) defines a plug as "a piece used to fill a hole", which is distinctively different from the *hole* itself.

Thus, the Applicants confuse themselves when using the term "*plug*" instead of "*hole*" on page 7 as recited in (a)-(c) above. In those passages the Applicants are using the word "plug" inconsistently with the accepted meaning. While applicant may be his or her own lexicographer, a term may not be given a meaning repugnant to the usual meaning of that term. See *In re Hill*, 161 F.2d 367, 73 USPQ 482 (CCPA 1947).

35 U.S.C. 112 § 1 Rejections

3. The following is a quotation of the first paragraph of 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

Claims 1, 5, 15, 18, and 20 are rejected under 35 U.S.C. 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention.

Claims 1, 5, 15, 18, and 20 recite the step of "depositing a metal layer in a feature", thus implicating that the "***feature***" is a ***hole***. However, Applicants' definition of the word "feature" as recited on page 7/lines 9-10, ".... complete formation of the desired feature as shown in Figure 12", as confirmed by the Fig. 12 itself, unambiguously defines the ***feature*** as a metal ***plug***.

The specification fails to convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention, since it does not give a clear definition as to what is meant by a "feature"recited in claims 1, 5, 15, 18, and 20.

Is Applicants' "feature" a plug, or a hole?.

35 U.S.C. 103 (a) Rejections

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Insofar as in compliance with 35 U.S.C. 112 § 1, claims 1-6, 8, and 11 are rejected under 35 U.S.C. 103(a) as being unpatentable over Taguchi et al. in view of Ho et al., and further in view of Bunshah's Handbook of Deposition Technologies for Films and Coating.

Taguchi et al. disclose a method of filling a *hole* [feature] formed in a dielectric layer, comprising:

a) depositing a generally conformal first barrier layer 3 in the *hole* [feature] shown in Fig.2a, as recited in Col.5/ll.4-6;

b) removing the first barrier layer 3 formed on the bottom of the *hole* [feature], as shown in Fig.2b, leaving only portions of barrier layer 3a on the walls 2a of the *hole* [feature], as recited in Col.5/ll.11-19;

c) sputter depositing a second barrier layer 4 under the conditions of a high density plasma, wherein the second barrier layer 4 comprises a material selected from a group consisting of Ta, TaN, TaSiN, TiSiN, and combinations thereof, as recited in Col.5/ll.20-23 and Col.9/ll.33-37, whereby the second barrier layer is made of TiN (Col.9/line 36).

It is a general knowledge in the art that Ta, TaN, Ti and TiN are equivalent alternatives for barrier layers (see e.g. Ho et al., Col.6/ll.9-13 & ll.41-47). Therefore, substituting TiN in Taguchi's

barrier layer 4 with Ta or TaN is not an act of invention, and hence, unpatentable. *In re Ruff*, 256 F.2d 590, 118 USPQ 340, 343 (CCPA 1958). Unpatentability not only applies where equivalency is disclosed in the prior art, but also where such equivalency would have been obvious. *Id.* at 599, 118 USPQ at 348.

It would have been obvious to one ordinarily skilled in the art at the time the invention was made to select any one of these materials as a suitable barrier layer 4 of Taguchi's, since it has been held to be within the general skill of a worker in the art to select a known material on the basis of its suitability for the intended use as a matter of design choice. *In re* Leshin, 125 USPQ 416.

However, Taguchi et al. do not recite the use of a high density plasma to specifically deposit the TiN barrier layer 4. Depositing TiN by means of reactive sputtering of Ti in the presence of a nitrogen plasma is a conventional method generally known in the art, as described, e.g., by Bunshah on page 321. The condition of "high density" plasma is well-known to one of ordinary skill in the art, as, e.g., described by Bunshah on page 325, reciting a gas pressure of 10^{-1} Torr and a neutral to ion density ratio of 10^4 : 1, corresponding to a plasma density of $3 \cdot 10^{11}$ cm^{-3}.

Taguchi et al. proceed the process with the steps of:

d) depositing a metal layer 5 in the *hole* [feature], as shown in Fig.2d and disclosed in Col.5/ll.20-23. However, Taguchi's metal layer 5 is not copper. Ho et al. deposits copper layer 26 shown in Fig.1b to fill the contact via holes 20 lined by Ta barrier layers 24 shown in Fig.1a.

It would have been obvious to one ordinarily skilled in the art at the time the invention to fill a via-hole formed in a dielectric layer according to the method of Taguchi et al. as modified by Ho

et al., thereby using reactive sputtering in the presence of a dense nitrogen plasma described under sputter ion plating as taught by Bunshah, since such a plasma assisted reactive sputtering is a standard and conventional method to deposit conformal TiN layer into via-holes at a high rate.

It would have been further obvious to one ordinarily skilled in the art at the time the invention to substitute Taguchi's Al-Si layer 5 in Fig.2d by Ho's copper layer, since copper is more desirable than aluminum owing to its lower resistivity and higher electromigration resistance.

- Regarding claim 2, the limitation that the 1st barrier layer is deposited using CVD techniques is disclosed by Taguchi et al. in Col.5/ll.4-6.
- Regarding claims 3 and 8, the limitation that the 1st barrier layer is comprised of Si_xN_y is disclosed by Taguchi et al. in Col.5/line 4.
- Regarding claim 4, the limitation that the 1st barrier layer formed on the bottom of the *hole* [feature] is removed using etching techniques is disclosed by Taguchi et al. in Col.5/ll.11-19
- Regarding claim 5, the limitation that the metal layer deposited in the *hole* [feature] is copper, is disclosed as copper layer 26 shown in Fig.1b filling the contact via holes 20 lined by TiN or Ta barrier layers 24 shown in Fig.1a, as recited in Col.6/ll.22-25 and Col.6/ll.41-47.
- Regarding claim 6, the limitation that the metal layer is deposited using CVD techniques is disclosed by Ho et al. in Col.6/ll.22-43.
- Regarding claim 11, the limitation that the second barrier layer is sputter deposited under the conditions of a high density plasma is a repeat of the process step as recited in claim 1 step (c). As

such, claim 11 is rejected under the same paragraph, reasons and prior arts as applied to claim 1 step(c) above.

It would have been obvious to one ordinarily skilled in the art at the time the invention to fill a via-hole formed in a dielectric layer according to the method of Taguchi et al. as modified by Ho et al., thereby using reactive sputtering in the presence of a dense nitrogen plasma described under sputter ion plating as taught by Bunshah, since such a plasma assisted reactive sputtering is a standard and conventional method to deposit conformal TiN layer into via-holes at a high rate.

It would have been further obvious to one ordinarily skilled in the art at the time the invention to substitute Taguchi's Al-Si layer 5 in Fig.2d by Ho's copper layer, since copper is more desirable than aluminum owing to its lower resistivity and higher electromigration resistance.

5. Insofar as in compliance with 35 U.S.C. 112 § 1, claims 7 and 12 are rejected under 35 U.S.C. 103(a) as being unpatentable over Taguchi et al. in view of Ho et al. and Bunshah's Handbook, and further in view of Barnes et al.

Taguchi et al. disclose a method of filling a via-hole formed in a dielectric layer, comprising steps that show all the limitations of claims 7 and 12, as applied to claims 1-5 above, except the recitation of depositing the metal layer by PVD methods (claim 7) and by sputter deposition under the conditions of a high density plasma (claim 12).

- Regarding claim 7, the step of depositing the metal layer by PVD methods is disclosed by Barnes et al. in Col.4/ll.2-4.

It would have been obvious to one with ordinary skill in the art at the time of the invention to modify Taguchi's method by Barnes's, i.e., depositing copper by PVD instead of CVD, since the PVD does not make use of any chemical reaction and is therefore free from residues that may contaminate and harm the product.

- Regarding claim 12, the limitation that the metal layer is sputter deposited under the conditions of a high density plasma using CVD techniques is disclosed by Ho et al. in Col.6/ll.22-43. Barnes's hole-filling materials include copper (Col.4/ll.2-4), which is deposited by a sputtering method under the conditions of a high density plasma (Col.6/ll.49-53 & ll.63-67).

It would have been obvious to one with ordinary skill in the art at the time of the invention to modify Taguchi's by Ho et al., i.e., using tantalum as a second barrier metal, and further modify by Barnes et al. to sputter-deposit copper under the conditions of a dense plasma. The benefits of using copper and tantalum have been previously discussed in regard of claim 6.

It would have been obvious to one with ordinary skill in the art at the time of the invention to sputter- deposit copper under the conditions of a dense plasma, owing to the increased deposition rate and the superior properties of the sputter grown films, as suggested by Barnes et al.,in Col.6/ll.67-68 and col.7/ll.1-5.

6. Insofar as in compliance with 35 U.S.C. 112 § 1, claims 13 and 14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Taguchi et al. in view of Ho et al., Bunshah's Handbook, and Barnes et al., and further in view of Kurino et al..

Taguchi et al. as modified by Ho et al., Bunshah's Handbook, and Barnes et al. show all the limitations of claims 13 and 14, as previously applied to claim 12, except the recitations of heating the metal layer to a temperature of between about room temperature and about 500^{0}C and then applying a pressure in the range of about 1000 psi to about 100,000 psi.

Kurino et al. describe a method of filling high aspect ratio via holes 21 & 22 shown in Fig.10b with a metal layer 20 shown in Fig.10d, wherein the metal layer 20 is heated to a temperature of between about 350^{0}C and 450^{0}C, as recited in Col.6/ll.43-44, and then subjecting the metal layer 20 to a pressurized environment in the range of about 580 psi (4MPa) to about 1,160 psi (8 MPa) as shown in Fig.10e, as recited in Col.6/line 46.

Generally, differences in pressure, temperature, or layer thickness will not support the patentability of subject matter encompassed by the prior art unless there is evidence indicating such pressure or temperature is critical. "Where the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation". *In re Aller*, 220 F.2d 454, 456, 105 USPQ 233, 235 (CCPA 1955).

A *prima facie* case of obviousness exists where the claimed ranges and prior art ranges do not overlap but are close enough that one ordinarily skilled in the art would have expected them to have the same properties. *In re* Titanium Metals Corporation of America v. Banner, 778 F.2d 775, 227 USPQ 773 (Fed. Cir. 1985).

It would have been obvious to one with ordinary skill in the art at the time of the invention to modify Taguchi's by Ho's, Bunshah's, and Barnes's , and further by Kurino's, in order to force the conductive material into the high aspect ratio holes, as taught by Kurino et al. in Col.5/ll.45-49.

7. Insofar as in compliance with 35 U.S.C. 112 § 1, claims 15-18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Taguchi et al. in view of Tseng et al.

Taguchi et al. disclose a method of filling a via-hole formed in a dielectric layer, comprising the steps of:

c) depositing a second generally conformal barrier layer 3 in the *hole* [feature] shown in Fig.2a and recited in Col.5/ll.4-6, as previously applied to claim 1 step (a);

d) removing the barrier layer 3 formed on the bottom of the *hole* [feature] shown in Fig.2b recited in Col.5/ll.11-19, leaving only portions of barrier layer 3a on the walls 2a of the *hole* [feature], as previously applied to claim 1 step (b) ;

e) selectively depositing a metal layer 5 in the *hole* [feature] as shown in Fig.2d and disclosed in Col.5/ll.20-23.

However, Taguchi et al. do not teach to deposit a first barrier layer over a blanket dielectric layer and form a via hole through the barrier layer and the dielectric layer to expose an underlayer. Tseng et al. perform, prior to step (c), a photolithographic patterning step comprising:

a) depositing a first barrier layer 8 over a blanket dielectric layer 7, as shown in Fig.2 and recited in Col.3/ll.37-41;

b) forming a *via hole* [feature] through the barrier layer 8 and the dielectric layer 7 to expose an underlayer 6, as shown in Fig.2 and recited in Col.3/ll.41-45.

It would have been obvious to one with ordinary skill in the art at the time of the invention to modify Taguchi's by Tseng et al., i.e., depositing a first barrier layer over a blanket dielectric layer, and then forming a via hole through the barrier layer and the dielectric layer, since these steps are conventional parts of a photolithographic patterning process to form a via hole through the barrier layer and the dielectric layer to expose an underlayer, whereby the barrier layer serves as an antireflection coating in the photolithographic process.

- Regarding claim 16, the limitation that the first barrier layer (Tseng's layer 8) and the second barrier layer (Taguchi's layer 3) are comprised of Si_xN_y is disclosed by Tseng et al. in Col.3/ll.37-41 and by Taguchi et al. in Col.5/line 4, respectively.

It would have been obvious to one with ordinary skill in the art at the time of the invention to continue Tseng's photolithographic patterning process immediately with Taguchi's method of filling the via holes with metal plugs, thereby leaving Tseng's silicon nitride antireflection coating and barrier layer essentially intact before starting with Taguchi's metallization process, since the first layer in Taguchi's is also a silicon nitride barrier layer.

- Regarding claim 17, the limitation that the barrier layer is deposited using CVD techniques is disclosed by Taguchi et al. in Col.5/ll.4-6. The limitation of depositing both the 1st and the 2nd barrier layers by the same (Taguchi's) method is trivial, since both barrier layers are made of the same material (Si_xN_y).

It would have been obvious to one with ordinary skill in the art at the time of the invention to modify Taguchi's by Tseng et al., thereby depositing the first barrier layer and second barrier layers according to Taguchi's method in order to simplify the process, since both barrier layers are of the same material silicon nitride.

- Regarding claim 18, the limitation that the barrier layer formed on the bottom of the *hole* [feature] is removed using sputter etching techniques is disclosed by Taguchi et al. in Col.5/ll.11-19.

8. Insofar as in compliance with 35 U.S.C. 112 § 1, claim 20 is rejected under 35 U.S.C. 103(a) as being unpatentable over Taguchi et al. in view of Ho et al. and Bunshah's Handbook, and further in view of Gardner and Barnes et al.

Taguchi et al. as modified by Ho et al. and Bunshah show all the limitations of claim 20, as applied previously to claim 5, except the limitation that the metal layer is deposited by first depositing a wetting layer using chemical vapor deposition techniques and then filling the hole [feature] using physical vapor deposition techniques.

Gardner deposit prior to the metal layer 202 in Fig.2e a wetting layer 206 using chemical vapor deposition techniques, as disclosed in Col.6/ll.21-41.

The step of filling the *hole* [feature] with a metal layer by PVD methods is disclosed by Barnes et al. in Col.4/ll.2-4.

9. Insofar as in compliance with 35 U.S.C. 112 § 1, claim 21 is rejected under 35 U.S.C. 103(a) as being unpatentable over Taguchi et al. in view of Tseng et al., and further in view of Ho et al.

Taguchi et al. as modified by Tseng et al. show all the limitations of claim 21, as applied previously to claim 15, except the limitation that the metal layer of claim 15 is copper. Ho et al. disclose that the metal layer used to fill-in the *hole* of claim 15 is copper, as shown by copper layer 26 shown in Fig.1b filling the contact via holes 20 lined by TiN or Ta barrier layers 24 shown in Fig.1a, as recited in Col.6/ll.22-25 and Col.6/ll.41-47.

Papers related to this application may be submitted directly to Art Unit 2814 by facsimile transmission. Papers should be faxed to Art Unit 2814 via the Technology Center 2800 fax center located in Crystal Plaza 4, room 4C23. The faxing of such papers must conform with the notice published in the Official Gazette, 1096 OG 30 (15 November 1989).

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Bernard E. Souw whose telephone number is (703) 305-3303. The examiner can normally be reached on Monday-Friday from 8:30 am to 5:00 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Olik Chaudury, can be reached on (703) 306-2794. The fax number for the organization where this application or proceeding is assigned is (703) 308-7722 or -7724.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the Technology Center receptionist at (703) 308-0956.

BES

Olik Chaudhuri

Bernard E. Souw

January 05, 2000